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PARASITOIDS OF *URABA LUGENS* WALKER (LEPIDOPTERA: NOCTUIDAE) IN SOUTH AUSTRALIA, WITH DESCRIPTION OF TWO NEW SPECIES OF BRACONIDAE

by A. D. AUSTIN & G. R. ALLEN*

Summary

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Information is presented on the large complex of hymenopteran and dipteran parasitoids associated with *Uraba lugens* Walker (the gumleaf skeletonizer) in South Australia. A key to the 22 species involved is presented, along with notes on identification and relationships with their host. Two species of microgastrine braconids are described, *Cotesia urabae* sp. nov. and *Dolichogenidea eucalypti* sp. nov.; both are parasitoids of the larval stages of *U. lugens*.

KEY WORDS: *Uraba lugens*, Noctuidae, parasitoids, hyperparasitoids, Braconidae, Ichneumonidae, Aphelinidae, Chalcididae, Elasmidae, Eulophidae, Eurytomidae, Eupelmidae, Trichogrammatidae, Tachinidae.

Introduction

Uraba lugens Walker, the gumleaf skeletonizer, is a native noctuid moth and has been collected from all states of Australia (Turner 1944). It has been recorded as damaging stands of eucalypt species in eastern Australia (Brimblecombe 1962; Campbell 1962; Harris 1972[1], 1974; Harris *et al.* 1977[2]), the Adelaide region and south-western Western Australia (pers. comm. F. D. Morgan; Strelein 1988). Occasionally outbreaks of this species can defoliate large areas of native forests. Several such outbreaks have occurred in stands of *Eucalpytus camaldulensis* Dehnh. along the Murray Valley region of N.S.W. and Victoria, where, on at least four occasions, more than 30,000 ha have been affected (e.g. Campbell 1962; Harris 1974; Harris *et al.* 1977[2]). Apart from the widespread damage associated with this species, it is also responsible for the partial defoliation of individual eucalypt trees planted as ornamentals in parks and gardens.

Other than the work of the above authors and those of Morgan & Cobbinah (1977) and Cobbinah (1983), very little has been published on the biology and ecology of *U. lugens*, while even less has been reported on its parasitoids. Brimblecombe (1962) reported five species of primary parasitoids as attacking *U. lugens* and Campbell (1962) ten species. However, in most cases these parasitoids were not identified further than family level and, if so, their identification was not reliable. One of us (G.R.A.) has recently completed a major study on the interaction of this insect and its parasitoids in the Adelaide region. This work shows that the immature stages of *U. lugens* support a diverse complex of hymenopteran and dipteran parasitoids (22 species — Table 1), which includes both primary parasitoids and hyperparasitoids. In this paper we provide a taxonomic framework for the information on the behaviour and ecology of this parasitoid complex and its interaction with *U. lugens*, which will be published elsewhere by G.R.A. Here we present a key to identify all the parasitoid species involved, and provide notes on their taxonomic position and biology, including information on the stage attacked and place of pupation. Two of the more common species reared from *U. lugens* larvae, which are members of the braconid subfamily Microgastrinae, and are the subject of detailed behavioural studies by G.R.A., are described here as new.

Materials and Methods

All life history stages of *U. lugens* were collected from eucalypts (mostly *E. camaldulensis*, *E. leucoxylon* F. Muell. and *E. microcarpa* (Maiden) Maiden) between 1985 and 1988 at several sites within 7 km of Adelaide G.P.O. They were brought to the laboratory, held at 20°C in rearing cages, and larvae provided with new foliage, so that any parasitoids present could develop and emerge normally. Parasitoid cocoons found with their dead host in the field were also collected and reared in the laboratory at 20°C until adults emerged.

[1] Harris, J. A. (1972) The effect of flooding on population density of the gum leaf skeletonizer moth, *Uraba lugens* Walk., in Barmah State Forest. Forest Commission, Victoria. Research Branch Report, No. 25 (unpubl).

[2] Harris, J. A. Neumann, F. G. & Ward, B. (1977) An outbreak of the gum leaf skeletonizer, *Uraba lugens* Walker, in river red gum forest near Barmah. Forest Commission, Victoria, Research Branch Report, No. 87 (unpubl).

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TABLE 1. *Summary of relationships between* U. lugens *and its parasitoids and hyperparasitoids*

Parasitoid species	Family	Primary (P) or Hyperparasitoid (H) Solitary (S) or Gregarious (G)	*U. lugens* stage attacked	Stage emerges from
Trichogramma sp.	Trichogrammatidae	P;S	egg	egg
Cotesia urabae	Braconidae	P;S	larva	larva
Dolichogenidea eucalypti	Braconidae	P;S	larva	larva
Euplectrus sp.	Eulophidae	P;S	larva	larva
Casinaria micra	Ichneumonidae	P;S	larva	larva
Exorista flaviceps	Tachinidae	P;S	larva	larva
Eriborus sp.	Ichneumonidae	P;S	larva	pupa
Xanthopimpla rhopaloceros	Ichneumonidae	P;S	pupa?	pupa
Antrocephalus sp.	Chalcididae	P;S	pupa	pupa
Brachymeria sp. 1	Chalcididae	P;S	pupa	pupa
Winthemia lateralis	Tachinidae	P;S	?	pupa?
Eurytoma sp.	Eulophidae	P;G/H;S	pupa?—	pupa/parasitoid cocoon
Centrodora sp.	Aphelinidae	H;G	—	parasitoid cocoon
Brachymeria sp. 2	Chalcididae	H;S	—	parasitoid cocoon
Elasmus australiensis	Elasmidae	H;G	—	parasitoid cocoon
species indet.	Eulophidae	H;G	—	parasitoid cocoon
Pediobius sp.	Eulophidae	H;G	—	parasitoid cocoon
species indet.	Eupelmidae	H;S	—	parasitoid cocoon
Anastatus sp.	Eupelmidae	H;G	—	parasitoid cocoon
Mesochorus sp.	Ichneumonidae	H;S	—	parasitoid cocoon
Paraphylax sp.	Ichneumonidae	H;S	—	parasitoid cocoon
Pteromalus sp.	Pteromalidae	H;S	—	parasitoid cocoon

Parasitoids were stored in a freezer or in 70% ethanol prior to mounting on pins or card points.

Material for S.E.M. study was washed in half strength concentrated liquid soap, rinsed in distilled water, dehydrated in an alcohol series and critical-point dried using an Emscope CPD 750, before being examined under a Cambridge Stereoscan 250 (Mk 3B) electron microscope. Terminology for morphology follows Bouček (1988), Eady (1968), Gauld (1984), Harris (1979), Mason (1986) and van Achterberg (1979). The term 'alitrunk' is used for the thorax plus propodeum, and 'gaster' is used for the post-propodeal segments. The abbreviation 'T' refers to the gastral tergites. Abbreviations for collections are: ANIC, Australian National Insect Collection, CSIRO, Canberra; WARI, Waite Agricultural Research Institute, Adelaide. Voucher specimens of all species are lodged in the Waite Institute collection.

Key to the parasitoids of *Uraba lugens* in South Australia

1. Two pairs of wings developed; dorsal surface very rarely with stout bristles; wasp-like in appearance (ovipositor always developed in female and usually clearly visible (Figs 5, 7, 29)) (Hymenoptera) 2
   Only one pair of wings developed (fore wings); dorsal surface with numerous stout bristles; blowfly like in appearance (Figs 48, 49) (scutum with several black longitudinal bands) (Tachinidae) 21

2. Fore wing with relatively complete venation (e.g. Figs 1, 2, 6, 19) 3
   Fore wing with pigmented venation reduced to anterior margin (e.g. Figs 21, 23, 27, 39) 9

3. Fore wing with venation distal to pterostigma wanting (Figs 1, 2); vein 2m-cu absent (Braconidae) 4
   Fore wing with distal veins present and well-pigmented; vein 2m-cu present (Figs 4, 20) (Ichneumonidae) 5

4. Propodeum with longitudinal medial carina, coarsely sculptured at least anteriorly (Fig. 12); legs red to red-yellow ..... *Cotesia urabae* sp. nov.
   Propodeum with large carinate areola and horizontal carinae extending to lateral margins of propodeum (Fig. 13); legs dark brown to black with distal parts reddish ..... *Dolichogenidea eucalypti* sp. nov.

5. Fore wing with an areolet (Figs 4, 6) 6
   Fore wing without an areolet (Figs 19, 20) 7

6. Scutum and propodeum coarsely punctate or rugulose; ovipositor very short (Fig. 5); ♂ genitalia without long rods protruding posteriorly (body dark brown to black, legs reddish) ..... *Casinaria micra* Ierman & Gauld
   Scutum and propodeum generally unsculptured (except for propodeal carinae); ovipositor extending well past posterior gaster (Fig. 7); ♂ genitalia with pair of long rods (gonosquama) protruding posteriorly (body yellow-brown with darker markings) ..... *Mesochorus* sp.

7. Body bright yellow with black markings; T1 short and broad basally (Fig. 16) ..... *Xanthopimpla rhopaloceros* Krieger
   Body not so coloured; T1 narrow basally (Figs 17, 18) 8

8. Fore wing with radial cell short and broad (Fig. 19); T1 flat, broadening distally (Fig. 17) (small species, length 2.3–3.2 mm not including ♀ ovipositor; body black except for T2 which is yellow-brown) ..... *Paraphylax* sp.
   Fore wing with radial cell long and narrow (Fig. 20); T1 tubular in basal half, bulbous in distal half (Fig. 18) (large species, length 6.5–8.7 mm not including ovipositor for ♀; head and alitrunk black, gaster reddish-brown ..... *Eriborus* sp.

9. Femur of hind leg greatly expanded, toothed or serrated along lower margin (Fig. 24) (Chalcididae) 10
Femur of hind leg normal, smooth along lower margin (Figs 25, 35) 12

10. Fore wing with marginal vein much longer than postmarginal vein (Fig. 22); apex of hind tibia tapering into strong spine (*Brachymeria*) 11
Fore wing with marginal vein about same length as postmarginal vein (Fig. 21); apex of hind tibia perpendicularly truncate (Fig. 24) (large species, 4.8 mm in length; body black, hind leg dark red-brown marked with black) ..... *Antrocephalus* sp.

11. Body black with red hind femur and tibia; 4.2–4.4 mm in length ..... *Brachymeria* sp. 1
Body black with white-yellow markings on tegulae and legs; 1.8–2.3 mm in length ..... *Brachymeria* sp. 2

12. Hind coxa developed as large flat disc; hind tibia with distinct criss-cross pattern of setae (Fig. 25) (fore wing with stigmal vein very short (Fig. 23), body dark, tegula and legs except for hind coxa pale; body length of ♀ 1.8–2.7 mm, ♂ 1.3–1.9 mm) (Elasmidae) ..... *Elasmus australiensis* Girault
Hind coxa, hind tibia and stigmal vein not as above 13

13. Pronotum (seen dorsally) large and quadrangular; dorsal surface of alitrunk coarsely sculptured (Fig. 26), fore wing venation as in Fig. 27 (body black and non-metallic, legs with some pale markings) (Eurytomidae) ..... *Eurytoma* sp.
Pronotum not large and quadrangular and alitrunk without such sculpturing; body often metallic in colour 14

14. Body length greater than about 1.5 mm; gaster separated from alitrunk by narrow waist (Figs 28, 29) 15
Body length less than 1.0 mm (minute species); gaster broadly attached to alitrunk or appearing so (Fig. 44) 20

15. Tarsi 5-segmented (cf. Figs 24, 25) 16
Tarsi 4-segmented (Fig. 35) 18

16. Mesopleuron not enlarged and shield-like (Fig. 28); body rather robust with large head and alitrunk (♀ gaster in lateral view sharply angled; ♂ gaster small and flattened; body length of ♀ 2.3–3.3 mm, ♂ 1.7–2.4 mm; metallic green in colour with yellow-brown legs and antennae) (Pteromalidae) ..... *Pteromalus* sp.
Mesopleuron large and shield-like; body somewhat elongate (Fig. 29) (Eupelmidae) 17

17. Dorsal surface of scutum flattened with raised anterior triangular area (Fig. 31); fore wing with broad pigmented bands (Fig. 30) (mostly dark in colour with metallic green tinge; body 2.1–2.5 mm in length) ..... *Anastatus* sp.
Dorsal surface of scutum not particularly flattened, without anterior raised area (Fig. 32); fore wings hyaline (head and alitrunk bright metallic green, gaster darker) ..... gen. & species indet. (♂ only)

18. Fore wing with stigmal and postmarginal veins very short (Fig. 34); anterior scutellum longitudinally striate (Fig. 33) (body dark with metallic green tinge, 1.1–1.5 mm in length) ..... *Pediobius* sp.
Fore wing with stigmal and postmarginal veins long (Fig. 37); scutellum smooth or with fine reticulate sculpturing 19

19. Dorsal head and alitrunk with scattered long bristle-like hairs (Fig. 36) (body mostly dark and non-metallic; eyes red; antennae, legs and broad patch on dorsal gaster yellow-brown) ..... *Euplectrus* sp.
Dorsal head and alitrunk with shorter finer hairs (dorsal alitrunk with distinctive metallic green and yellow markings (Fig. 38)) ..... gen. & species indet.

20. Tarsi 3-segmented (Fig. 40); antennae 5-segmented (Figs 41, 42); fore wing very broad (Fig. 39) (Trichogrammatidae) ..... *Trichogramma* sp.
Tarsi 5-segmented (Fig. 47); antennae 6-segmented (Figs 45, 46); fore wing narrower (Fig. 43) (Aphelinidae) ..... *Centrodora* sp.

21. Hairs covering occiput (posterior part of head) silver-grey; abdomen in dorsal view with anterior, medial and posterior parts black, lateral areas brown (Fig. 48) ..... *Winthemia lateralis* (Macquart)
Hairs covering occiput golden brown, 1st segment of abdomen black, other segments black with patches of silver (Fig. 49) ..... *Exorista flaviceps* Macquart

Treatment of species

HYMENOPTERA

Family Braconidae

Cotesia urabae sp. nov.

FIGS 2, 8, 10–12, 14

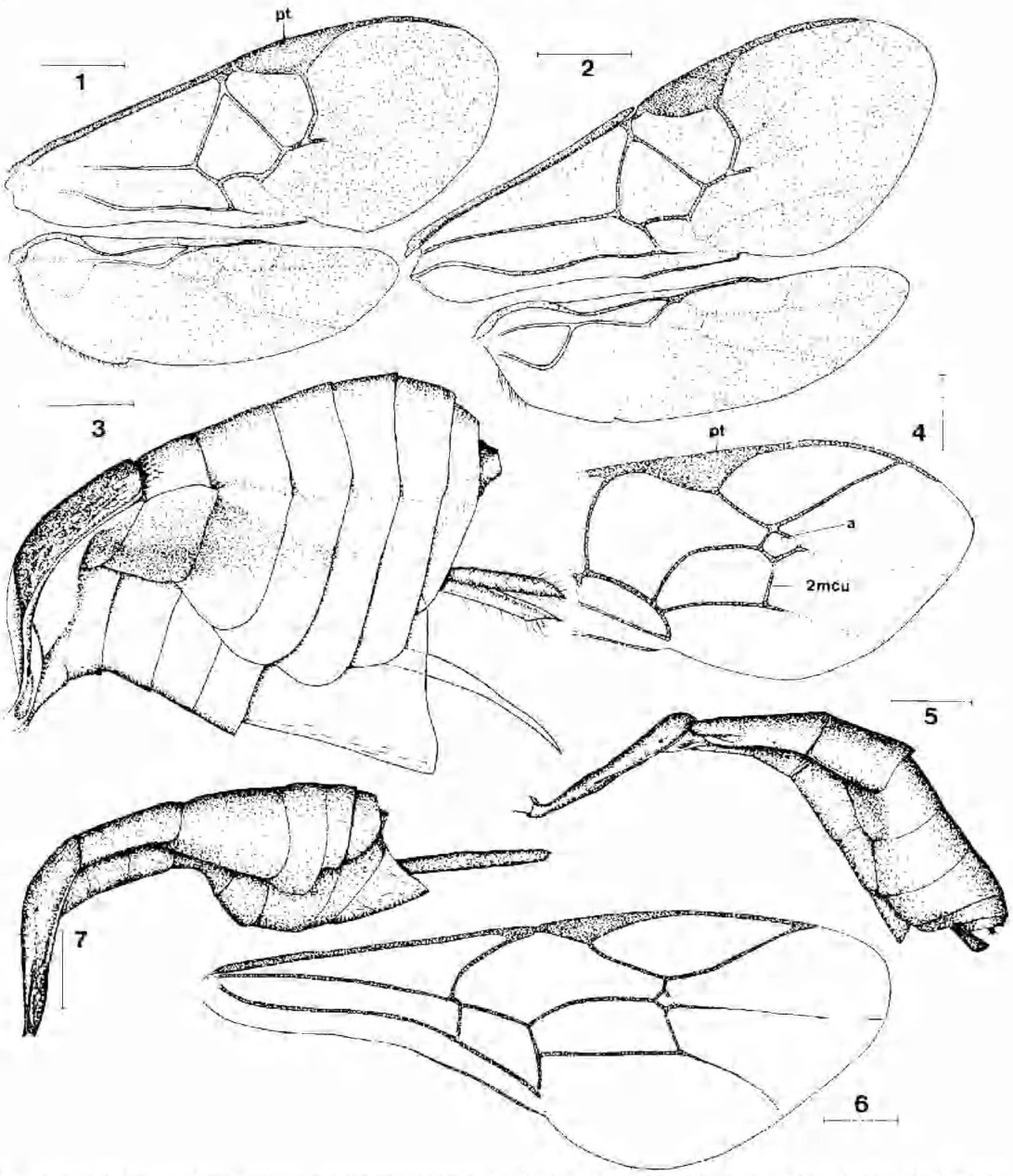
Holotype: ♀, ANIC, S. Aust., Adelaide (Mitcham), reared ex *Uraba lugens* on *Eucalyptus microcarpa*, coll. 14.x.1985, emerged 3.xi.1985, G. R. Allen. Paratypes: 8♀ ♀, 20♂ ♂, same data as holotype except some with different suburbs of Adelaide and different dates; 17♀ ♀, 13♂ ♂, S. Aust., Adelaide (Waite Institute campus), various collecting and emergence dates during 1964, I. Hope, 5♀ ♀, 1♂, S. Aust., National Park, Belair, coll. 20.xi.1964, emerged 25.xi.1964, F.D.M. (5♀ ♀, 5♂ ♂, ANIC; rest of material including 1♀ gold coated for SEM (wings slide-mounted) in WAR.).

Female

Length. 2.9 mm (2.5–3.2 mm, n = 10) including ovipositor.

Colour. Body black; palps yellow; legs except for coxa yellow-brown, hind leg infuscate distally, distal end of hind tibia with dark patch; anterior pleural-sternal region of gaster dark red; wings hyaline, stigma evenly and darkly pigmented, as is rest of fore wing venation.

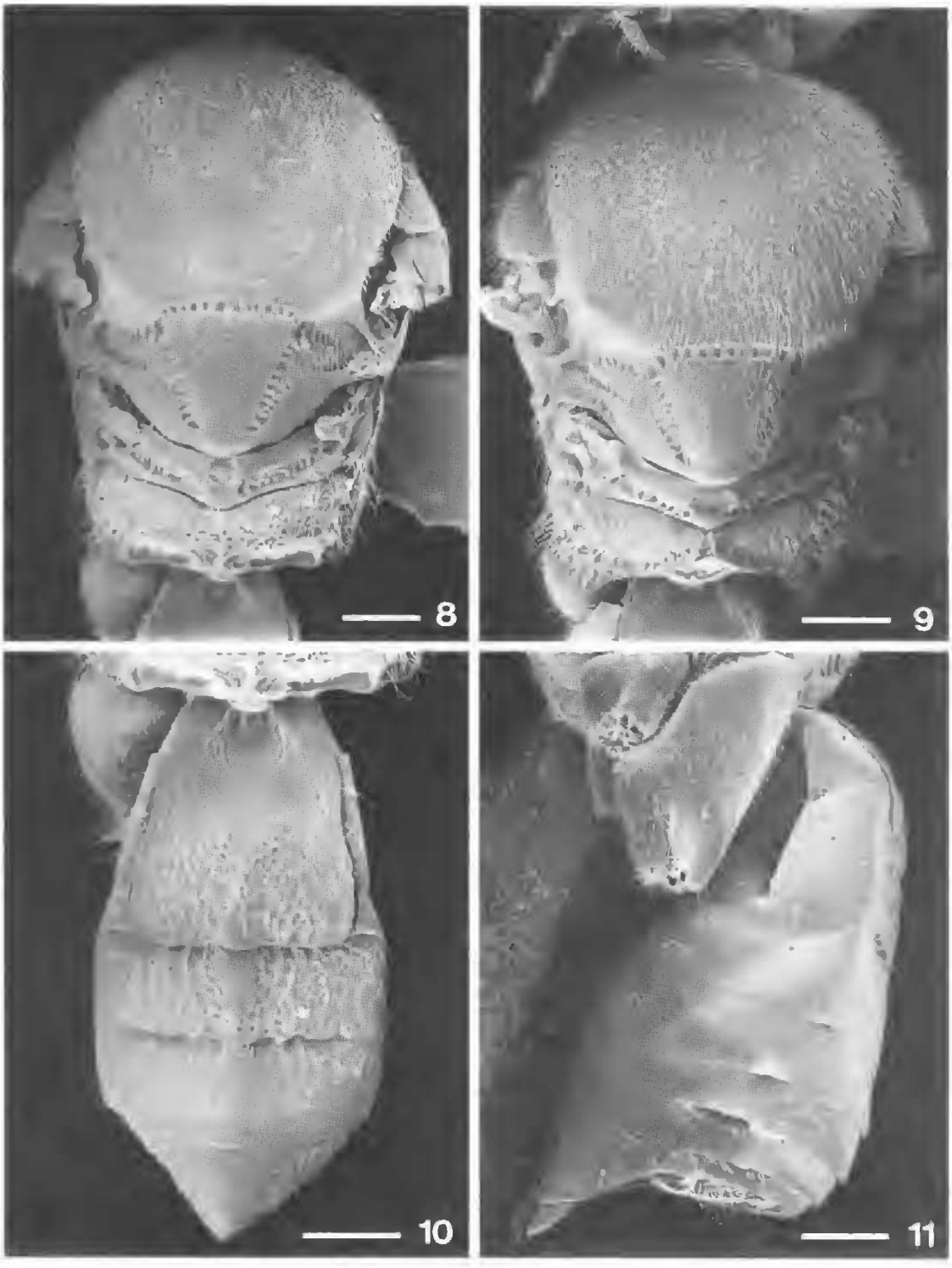
Head. In anterior view vertex arched so that head is somewhat circular; face and gena with longish white hairs and associated fine colliculate sculpturing; inner margins of eyes virtually parallel; in dorsal view ocelli in wide triangle, posterior tangent of median ocellus coincident with imaginary line across the anterior margins of lateral ocelli; frons and medial occiput smooth and hairless; temples with white hairs and associated colliculate sculp-



Figs 1–7. 1–2, Fore and hind wings: 1, *Dolichogeniaea eucalypti* sp. nov., ♀; 2, *Cotesia urabae* sp. nov., ♀; 3, Lateral view of gaster of *Dolichogenidea eucalypti* sp.nov., ♀; 4, Distal fore wing of *Mesochorus* sp., ♀; 5–6, *Casinaria micra* Jerman & Gauld, ♀; 5, Lateral view of gaster; 6, Fore wing; 7, Lateral view of gaster of *Mesochorus* sp., ♀. Scales: Figs 1, 2, 4 and 6 = 0.5 mm; Fig. 3 = 200 μm; Figs 5 and 7 = 1.5 mm. Abbreviations: a = areolet; pt = pterostigma.

turing which is slightly coarser than on face; vertex with few scattered short hairs otherwise smooth; antennae slightly longer than body, distal 4–5 segments only slightly longer than wide.

Alitrunk. Scutum punctate with covering of shortish hairs, punctation denser along courses of notauli and along lateral margins (Fig. 8), punctation along posterior margin becoming slightly longitudinally elongate; courses of notauli faintly depressed, these faint depressions broadening posteriorly; scutellum faintly punctate; phragma of scutellum exposed along posterolateral margins (Fig. 8); propodeum



Figs 8–11. 8–9, Dorsal view of alitrunk: 8, *Cotesia urabae* sp. nov., ♀; 9, *Dolichogenidea eucalypti* sp. nov., ♀; 10–11, *Cotesia urabae* sp. nov., ♀; 10, Dorsal view of gaster; 11, Lateral view of gaster. Scales: = 200 μm.

coarsely rugose to rugose-striate in anterior half, generally smooth with faint rugose punctation in posterior half; medial longitudinal carina well developed with associated short horizontal and oblique carinae (Fig. 12); mesopleuron finely punctate in anterior half with associated short hairs, smooth and hairless in posterior half except for compact group of 5–6 foveae medially; metapleuron smooth anteriorly, rugose-punctate posteriorly (Fig. 14); hind coxa faintly punctate on dorsal surface with associated short hairs, this sculpturing becoming coarser on ventral surface.

Wings. Fore wing with veins r and 2-SR sharply angled, r slightly longer than 2-SR; cu-a almost striate; distal part of basal cell and anterior part of sub-basal cell devoid of hairs or almost so; discal cell sparsely covered with hairs; hind wing with vein r (spectral) present (Fig. 2).

Gaster. T1 as wide as long, broadening posteriorly, surface in posterior two-thirds coarsely punctate to rugose-punctate, becoming coarsely striate in posterior one-quarter (Fig. 10); sclerotized part of T2 rectangular, slightly wider than T1, coarsely rugose-punctate with a few longitudinal striations, sculpturing fading to nearly smooth in postero-lateral corners, longitudinal midline smooth; T3 usually rugose-punctate in anterior one-quarter to two-thirds, with scattered hairs, posterior part smooth, in some specimens T3 virtually smooth throughout but always with at least anterior margin with band of punctation; rest of tergites smooth with scattered hairs; in lateral view hypopygium pointed, extending past posterior gaster, with scattered fine hairs, ventroapical margin not indented (Fig. 11); ovipositor sheaths with few apical hairs.

Male

As for female except for length, 2.8 mm (2.6–3.1 mm, n = 10) and sexual differences (genitalia and development of hypopygium).

Other material examined: S. Aust., suburbs of Adelaide, various dates and collectors, 10♀♀, 16♂♂ -WARI (excluded from type series because material is damaged or inadequately labelled).

Comments: The sculpturing on the propodeum and T1–T3, the shape of these sclerites, the form of the hypopygium and ovipositor, clearly place this species in *Cotesia* Cameron. *Cotesia* has previously been referred to as the *glomeratus* species-group of *Apanteles s.l.* (see Mason 1981; Nixon 1965), and is the largest generic level taxon in the subfamily Microgastrinae, the latter comprising some 1300–1500 described species world-wide (Mason 1981). In Australia *Cotesia* is common and diverse, but other than several species introduced from Europe and North America as bio-control agents for certain lepidopteran pests (viz. *C. flavipes* Cameron, *C. glomerata* (L.) *C. kuzak* (Telenga), *C. marginiventris* (Cresson), *C. plutellae* (Kurdjumov), *C. rubecula* (Marshall) and *C. ruficrus* (Haliday)), the Australian fauna remains unstudied. A few poorly characterized species, which presently remain under the name *Apanteles s.l.*, may turn out to belong in *Cotesia*. These species are unlikely to be conspecific with the present species as their type localities are outside the known distribution of *C. urabae* sp. nov. or they are associated with other hosts. There are no workable keys to Indo-Australian species of *Cotesia*. However, the key in Nixon (1974) to the north-western European fauna can be used to separate *C. urabae* sp. nov. from four of the seven introduced species mentioned above. Of the other three species, *C. flavipes*, is very different to *C. urabae* sp. nov. in that its body is strongly flattened dorsoventrally (see Austin 1989), while *C. kuzak* and *C. marginiventris* can only be identified reliably in association with their hosts, *Helicoverpa* spp. and *Mythimna convecta* (Walker), respectively.

Biology: *C. urabae* sp. nov. is a solitary, primary endoparasitoid and oviposits into early to intermediate larval instars of its host, emerging from intermediate to late instars before pupating. The pupal cocoon is alongside the host and is sulphur yellow-green with a surrounding silk matrix. This species has only been reared from *U. lugens*.

Dolichogenidea eucalypti sp. nov.
FIGS 1, 3, 9, 13, 15

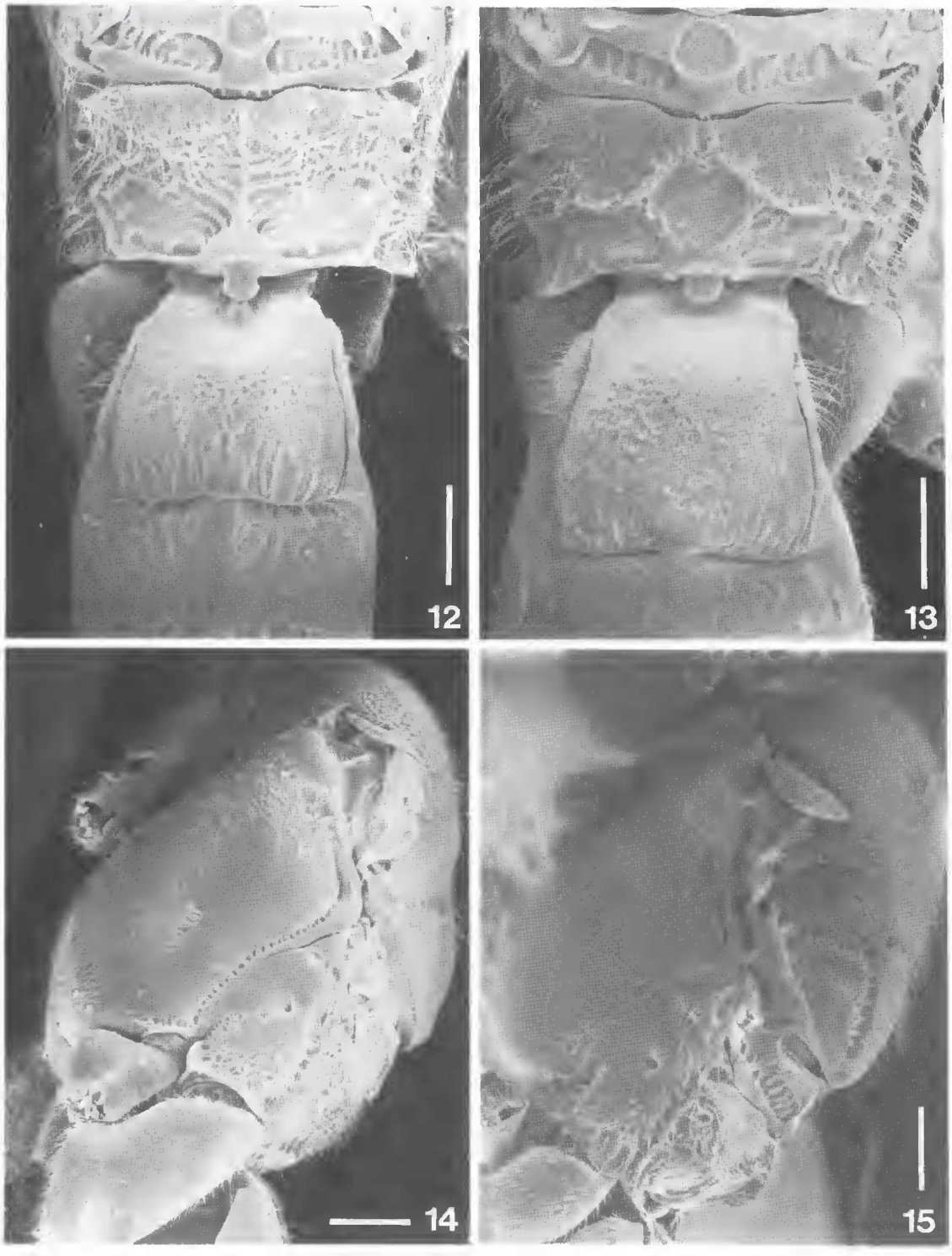
Holotype: ♀, ANIC, S. Aust., Adelaide (Highgate), reared ex *Uraba lugens* on *Eucalyptus camaldulensis*, collected 1.xi.1985, emerged 17.xi.1985, G. R. Allen. Paratypes: 15♀♀, 20♂♂ same data as holotype except some with different suburbs of Adelaide and different dates; 13♀♀, 5♂♂, S. Aust., Adelaide (Waite Institute campus), various collecting and emergence dates during 1964, L. Hope (5♀♀, 5♂♂, ANIC; rest of material including 1♀ gold coated for SEM (wings slide-mounted) in WARI).

Female

Length. 2.9 mm (2.5–3.1 mm, n = 10) including ovipositor.

Colour. Body black, wings hyaline with darkly pigmented venation, palps brown, legs black with distal fore legs, tarsi of mid and hind legs and tibio-femoral joint yellow-brown.

Head. Mostly smooth except for fine colliculate sculpturing associated with dense covering of short



Figs 12–15. 12–13, Propodeum and first and second tergites of gaster: 12, *Cotesia urabae* sp. nov., ♀; 13, *Dolichogenidea eucalypti* sp. nov., ♀; 14–15, Lateral view of alitrunk: 14, *Cotesia urabae* sp. nov., ♀; 15, *Dolichogenidea eucalypti* sp. nov., ♀. Scales: = 200 μm.

hairs; surface with characteristic dull lustre; in anterior view inner margins of eyes virtually parallel; in dorsal view ocelli forming wide triangle, posterior tangent of median ocellus coincident with imaginary line across the anterior margins of lateral ocelli; fine colliculate sculpturing and associated pilosity slightly denser across vertex and occiput, except for smooth narrow band around posterior margins of eyes; antennae reaching to posterior gaster or slightly beyond, distal three segments slightly longer than wide and sometimes slightly compressed.

Alitrunk. Scutum coarsely punctate with punctures mostly closer to each other than their own diameter, except along posterior border and along courses of notauli, which are thus faintly indicated (Fig. 9); scutellum smooth; scutum and scutellum densely covered with short hairs; metanotum rather broad, anterolateral margins emarginate so that phragma of scutellum well exposed; carinae forming propodeal areola raised well above surface, carinae extending laterally below horizontal midline, these carinae with dorsal and ventral extensions forming cristulae, but not enclosing spiracles (Fig. 13); anterior part of propodeum mostly smooth and setose, posterior part with faint rugose-punctate sculpturing which becomes more obvious laterally; mesopleuron setose in anterior half, smooth posteriorly; metapleuron mostly smooth, except for ventroposterior one-third which is rugose-punctate (Fig. 15); distal fore tarsus without spine opposed to tarsal claw.

Wings. Fore wing venation as in Fig. 1; costal and basal cells bare posteriorly; hind wing broad; vein 1-SC+R deeply bowed; r present but faint; cubitellan cell moderately broad; submediellan cell rounded posteriorly.

Gaster. T1 as wide as long, slightly widened in posterior half, lateral margins slightly emarginate, surface mostly punctate, striate-punctate along lateral margins and striate in posterolateral corners and along posterior margin (Fig. 13); sclerotized part of T2 slightly wider than T1, 2.5 x wider than long, mostly smooth with faint scattered punctures; T3 slightly longer than T2 (14:11); T4–T6 shorter than T2 (8:11); T7 very short, about one-quarter length of T2; T3–T6 all smooth; T2–T7 each with single transverse row of hairs; ovipositor and sheaths short, not extending far past posterior gaster; ovipositor with strong distal attenuation (Fig. 3); hypopygium lacking obvious lateral creases though weakened normally in ventral midline.

Male

As for female except as follows: Length 2.7 mm (2.5–2.8 mm, n = 10); alitrunk very slightly flattened dorsoventrally; fore wing stigma unpigmented in medial area so that it is transparent; rest of wing venation generally with less pigmentation than female; T1 sometimes with dense rugose-punctate sculpturing merging with posterior striations, otherwise same as female except for male genitalia and lacking hypopygium.

Comments: The sculpturing of the scutum and propodeum, shape of T1 and T2, form of the hypopygium, and shape and fringe of the vannal lobe of the hind wing clearly place this species in *Dolichogenidea* Viereck. Previously *Dolichogenidea* was considered as three related species-groups in the genus *Apanteles s.l.*, viz. the *ultor, laevigatus* and *longipalpis* species-groups (see Mason 1981; Nixon 1965, 1967). This species falls into the *ultor* group which was revised by Nixon (1967) for the Indo-Australian region. In this work *D. eucalypti* sp. nov. keys out to *D. cleo* (Nixon) (couplet 23), a species known only from India and associated with a nymphalid host *Eriboae arja* Felder, or with some difficulty it keys as *D. caniae* (Wilkinson) (couplet 31), which is known only from Java and associated with a limacodid, *Cania bandura* Moore (Austin 1987). Apart from having different hosts, these species differ from *D. eucalypti* sp. nov. in that *D. caniae* has an unusual striate sculpturing pattern on T1 and T2, and *D. cleo* has the sub-basal cell evenly and darkly setose, the hind femur yellow in colour, the proximal half of the ovipositor very broad, and the mesopleuron coarsely rugose-punctate anteriorly. This is the fourth species of *Dolichogenidea* recorded from Australia, the others being *D. lipsis* (Nixon) comb. nov., *D. miris* (Nixon) comb. nov. and *D. tasmanica* (Cameron) comb. nov. Examination of the holotypes of these species shows that they differ from *D. eucalypti* sp. nov. in a number of important characters. All three have the ovipositor much longer, being at least as long as the hind tibia, and, in addition, *D. lipsis* and *D. tasmanica* have a white spot on the cheek and a much reduced propodeal areola. These species can be readily separated from *D. eucalypti* sp. nov. using the key in Nixon (1967).

Biology: D. eucalypti sp. nov. is a solitary, primary endoparasitoid which oviposits into early to intermediate larval instars of its host, emerging from intermediate to late instars before pupating. The pupal cocoon is spun alongside the host and is white in colour and lacks a surrounding silk matrix. This species has only been reared from *U. lugens*.

Family Ichneumonidae

Xanthopimpla rhopaloceros Krieger

FIG. 16

This species is easily identified by its distinctive colour pattern and fore wing venation. In South Australia it is known from two specimens (WARI), one collected as an adult in the Adelaide region, the other reared from *U. lugens* at Keith. It is also known from Queensland and Tasmania where it has been recorded from *U. lugens*, and the tortricids *Epiphyas postvittana* (Walker) and *Merophyas divulsana* (Walker) (Brimblecombe 1962; Dumbleton 1940; Gauld 1984; also see Townes & Chui 1970). It is a solitary, primary endoparasitoid and emerges from the pupal stage of its host. See Gauld (1984) for additional taxonomic information and list of synonyms.

Paraphylax sp.
FIGS 17, 19

Paraphylax is a large Old World genus with more than 50 recognized species from Australia, the majority of which are undescribed (Gauld 1984). Where their biology is known *Paraphylax* spp. have been recorded as primary and hyperparasitoids, mostly of lepidopteran hosts. Apart from the characters given in the key this species is notable in comparison to other parasitoids associated with *U. lugens* for its relatively smooth unsculptured body (except for propodeal carinae) and lateral teeth on the propodeum. The species here belongs to the *corvax* species-group (see Gauld 1984) and is only known from the Adelaide region, where it has been reared as an obligate, solitary hyperparasitoid through *C. urabae* and *D. eucalypti*.

Eriborus sp.
FIGS 18, 20

This is a distinctive species when compared to the other ichneumonids associated with *U. lugens*. In addition to the characters given in the key this species has distinctive reticulate-punctate sculpturing on the scutum, scutellum and propodeum. *Eriborus* sp. is a solitary primary parasitoid of *U. lugens*, ovipositing into the larval stages and emerging from the pupa. It is only known from the Adelaide region and has been reared from its host on various occasions since 1965 (WARI, unpublished records).

Casinaria micra Jerman & Gauld
FIGS 5, 6

This species is a solitary, primary endoparasitoid easily recognized by its fore wing venation, short ovipositor and colour. It has been recorded from all states in Australia and, although it has been most commonly associated with *U. lugens*, *C. micra* has been reared from species belonging to three other distantly related lepidopteran families — Geometridae, Oecophoridae, Notodontidae (see Gauld 1984; Jerman & Gauld 1988). The pupal cocoon is constructed near to (Jerman & Gauld 1988) or underneath (observations in this study) its dead larval host and is attached firmly to the leaf surface. It is grey-brown and marked with characteristic black spots. See Jerman & Gauld (1988) for additional taxonomic information and list of synonyms.

Mesochorus sp.
FIGS 4, 7

This is a large cosmopolitan genus of primary and hyperparasitoids of lepidopteran and coleopteran hosts; most Indo-Australian species are undescribed (Gauld 1984). The species recorded here is a solitary obligate hyperparasitoid of *U. lugens* through *C. micra*, *C. urabae* and *D. eucalypti*, and is known only from the Adelaide region. It is a pale coloured delicate species with fine thread-like antennae. The male is distinctive in having the gonosquama of the genitalia extending from the posterior gaster as a pair of long rods.

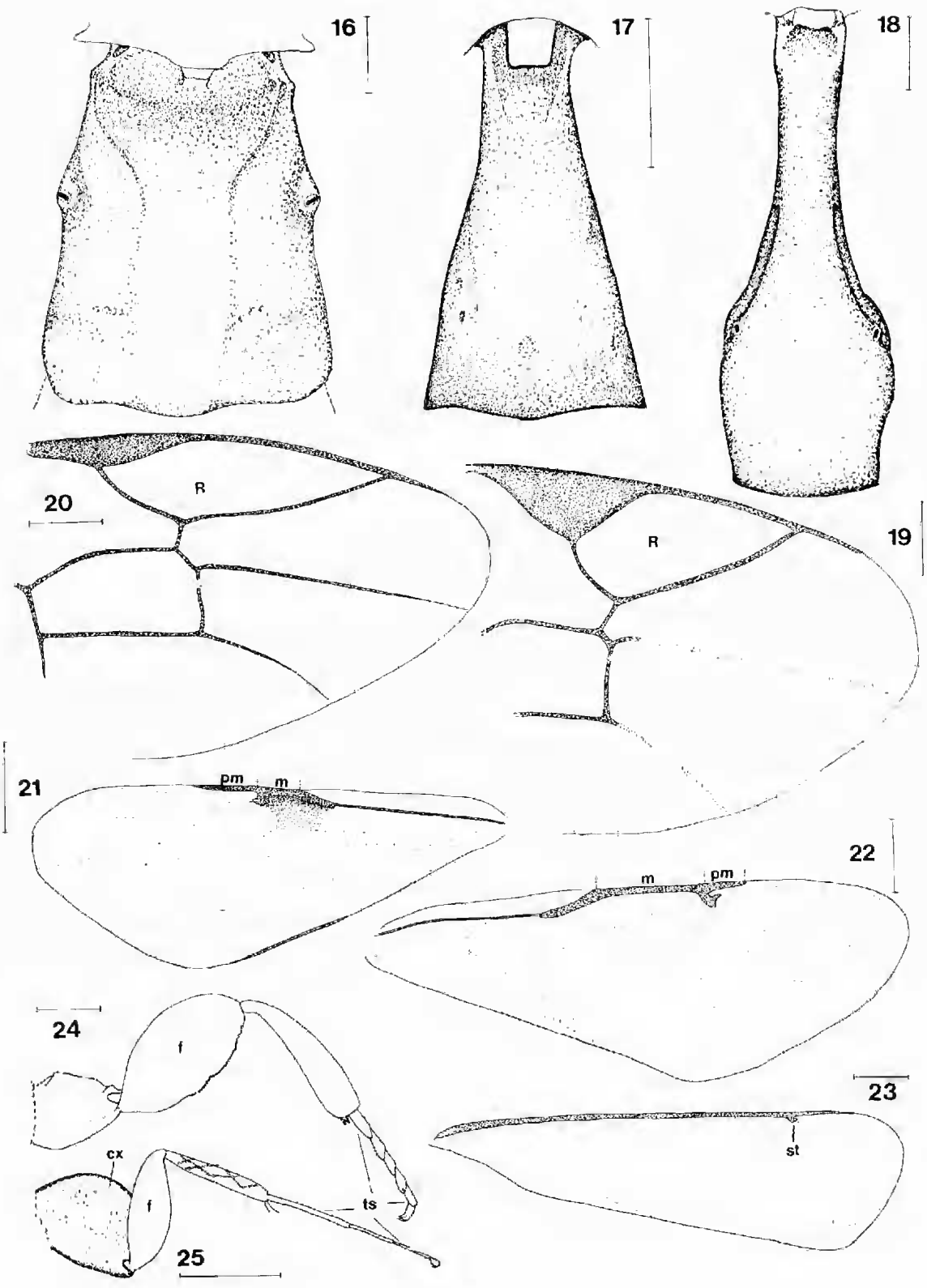
Family Chalcididae

Brachymeria spp.
FIG. 22

This is a large genus in Australia with nearly 70 described species, the majority of which are primary, pupal parasitoids of Lepidoptera (Bouček 1988). The two species recorded here (both unidentified) can be separated easily by the characters in the key. Species 1 is a solitary, primary parasitoid of *U. lugens* and emerges from the host pupa. Species 2 is solitary and hyperparasitic through *C. urabae* and *D. eucalypti*, though it is not known whether this relationship is facultative or obligatory. In eastern Australia two species of *Brachymeria* have been reared from *U. lugens*, viz. *B. froggatti* (Cameron) (Brimblecombe 1962) and *B. rubripes* Girault (Campbell 1962) (*B. rubripes* is considered a junior synonym of *B. teuta* (Walker); see Bouček 1988). However, the material from these records would have been identified at a time when the Australian species in the genus were confused by most authors and hence might be misidentified. These names should thus be used with some care, especially since Bouček (1988) did not see any material in Australian collections or elsewhere reared from *U. lugens* that he could assign to either *B. froggatti* or *B. teuta*.

Antrocephalus sp.
FIGS 21, 24

This species is represented here by a single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specimen reared as a primary parasitoid from the pupa of *U. lugens* in the Adelaide region. It is easily distinguished by the characters in the key. There are more than 60 described Australian congeners which are discussed by Bouček (1988).

Family Eurytomidae

Eurytoma sp.
FIGS 26, 27

This is a large cosmopolitan genus with more than 60 described Australian species (Boucek 1988). Biologically the group is very diverse including phytophagous species, primary parasitoids (mostly of lepidopteran hosts) and hyperparasitoids. The species recorded here develops as either a primary gregarious parasitoid of *U. lugens*, or as a solitary hyperparasitoid through *C. urabae*.

Family Pteromalidae

Pteromalus sp.
FIG. 28

This species is relatively easily separated from other Chalcidoidea associated with *U. lugens* by its robust body and metallic green colour. The genus is taxonomically very complex and the Australian species are in need of revision (Bouček 1988). The species recorded here is an obligate, solitary hyperparasitoid reared from *U. lugens* through *C. micra*, *C. urabae* and *D. eucalypti* in the Adelaide region.

Family Elasmidae

Elasmus australiensis Girault
FIGS 23, 25

A distinctive species recorded here as an obligate, solitary hyperparasitoid of *U. lugens* through *C. micra*, *C. urabae* and *D. eucalypti*. Previously it was known to be hyperparasitic and occasionally gregarious through an unknown ichneumonid associated with *U. lugens* in the A.C.T., and also has been collected from N.S.W., and northern and southern Qld (type locality: Gordonvale, Qld). This is the first record of *E. australiensis* from S. Aust., indicating that it is probably distributed throughout south-eastern Australia. See Riek (1967) for additional taxonomic information and list of synonyms.

Family Eulophidae

Euplectrus sp.
FIGS 36, 37

Euplectrus is a cosmopolitan genus of gregarious ectoparasitoids of lepidopteran larvae, which is represented in Australia by 13 described species (Bouček 1988). The species recorded here is solitary and only known from the Adelaide region. It attacks the early to intermediate larval stages, killing them before they pupate while pupating itself underneath the dead host.

Pediobius sp.
FIGS 33–35

This is a large, cosmopolitan genus of primary and hyperparasitoid species that attack a wide range of insect groups (Bouček 1988). There are more than 30 described Australian species, most of which do not have associated host information (Bouček 1988). The unidentified species recorded here is easily distinguished from other Hymenoptera associated with *U. lugens* by its distinctive venation and sculpturing on the scutellum. It is represented by four specimens (WARI) reared in the Adelaide region from *U. lugens* and developed as a solitary hyperparasitoid through *Euplectrus* sp. and as a gregarious hyperparasitoid through *D. eucalypti*.

Eulophidae (genus & species indet.)
FIG. 38

The two specimens reared as hyperparasitoids of *U. lugens* through *D. eucalypti* in the Adelaide region could not be identified to genus due to the poor condition of the material. They are different from the other eulophids recorded here and can be distinguished by the dorsoventrally flattened body and distinctive colour pattern.

Family Eupelmidae

Anastatus sp.
FIGS 29–31

This species is easily separated from the other chalcidoids associated with *U. lugens* by its distinctive body shape and banded wings. The genus is cosmopolitan and known mainly as parasitoids of the eggs of Lepidoptera and Heteroptera,

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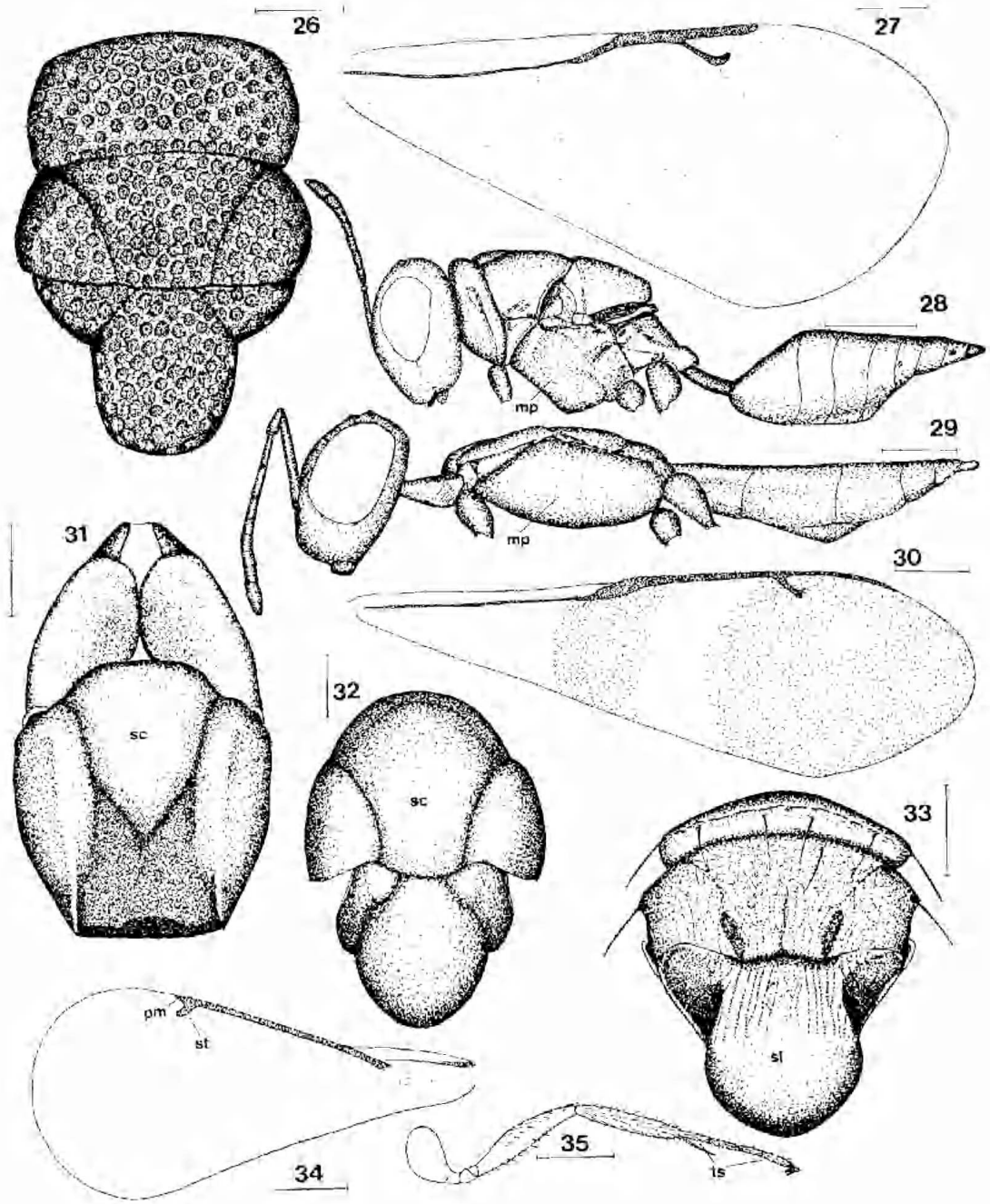
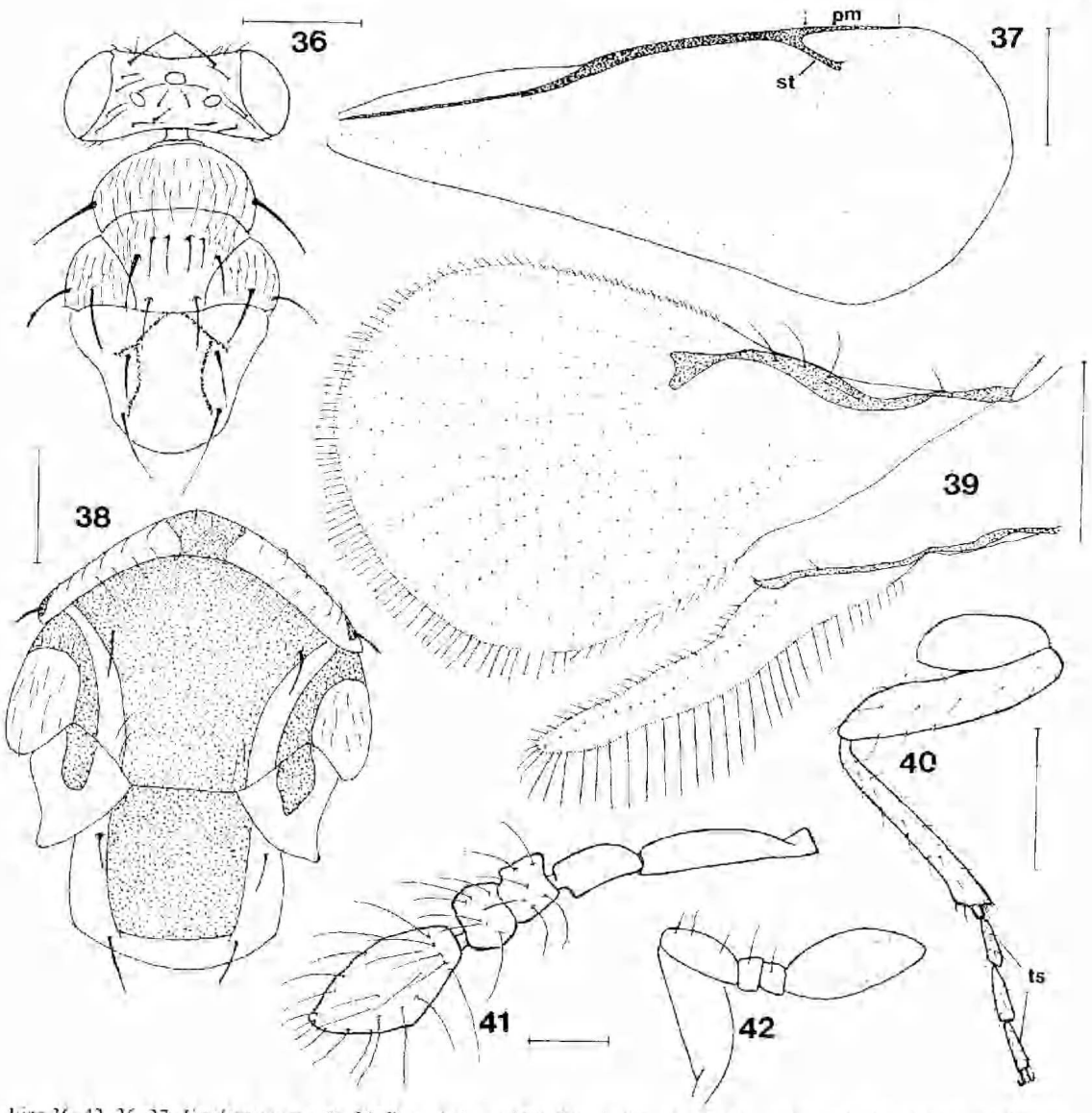
Figs 16–25. 16–18, First tergite of gaster: 16, *Xanthopimpla rhopaloceros* Krieger, ♀; 17, *Paraphylax* sp., ♀; 18, *Eriborus* sp., ♀. 19–20, Distal fore wings: 19, *Paraphylax* sp., ♀; 20, *Eriborus* sp., ♀. 21–23 Fore wings: 21, *Antrocephalus* sp., ♀; 22, *Brachymeria* sp. 2, ♀; 23, *Elasmus australiensis* Girault, ♀. 24–25, Hind legs: 24, *Antrocephalus* sp., ♀; 25, *Elasmus australiensis* Girault, ♀. Scales: Figs 16–19 = 250 μm; Figs 20 and 24 = 0.5 mm; Fig. 21 = 0.8 mm; Fig. 22 = 250 μm; Fig. 23 = 200 μm; Fig. 25 = 1.0 mm. Abbreviations: ax = coxa; f = femur; m = marginal vein; pm = postmarginal vein; R = radial cell; st = stigmal vein; ts = tarsal segments.



Figs 26–35. 26–27, *Eurytoma* sp., ♀; 26, Dorsal view of alitrunk; 27, Fore wing; 28–29, Lateral view of body: 28, *Pteromalus* sp., ♀, 29, *Anastatus* sp., ♀; 30, Fore wing of *Anastatus* sp., ♀; 31–33, Dorsal view of alitrunk: 31, *Anastatus* sp., ♀; 32, Eupelmidae, genus & species indet., ♂; 33, *Pediobius* sp., ♀; 34, fore wing of *Pediobius* sp., ♀, 35, Hind leg of *Pediobius* sp., ♀. Scales: Figs 26, 27, 29, 34 and 35 = 250 μm; Fig. 28 = 0.5 mm; Fig. 30 = 200 μm; Figs 31–33 = 150 μm. Abbreviations: mp = mesopleuron; pm = postmarginal vein; sc = scutum; sl = scutellum; st = stigmal vein; ts = tarsal segments.



Figs 36–42. 36–37, *Euplectrus* sp., ♀; 36, Dorsal view of head and alitrunk; 37, Fore wing; 38, Dorsal view of alitrunk of Eulophidae, genus & species indet., ♀ (stippling indicating colour pattern); 39–42, *Trichogramma* sp.: 39, Fore and hind wings, ♂; 40, Hind leg, ♀; 41, ♂ antenna; 42, ♀ antenna. Scales: Figs 36 and 37 = 250 μm; Figs 38 and 39 = 150 μm; Fig. 40 = 100 μm; Figs 41 and 42 = 50 μm (same scale line). Abbreviations: pm = postmarginal vein; st = stigmal vein; ts = tarsal segments.

although a few are recorded as hyperparasitoids through braconids. *Anastatus* is represented in Australia by 40 described species (Bouček 1988). The species recorded here is represented by three specimens reared as a gregarious hyperparasitoid through *C. urabae* and *D. eucalypti* in the Adelaide region.

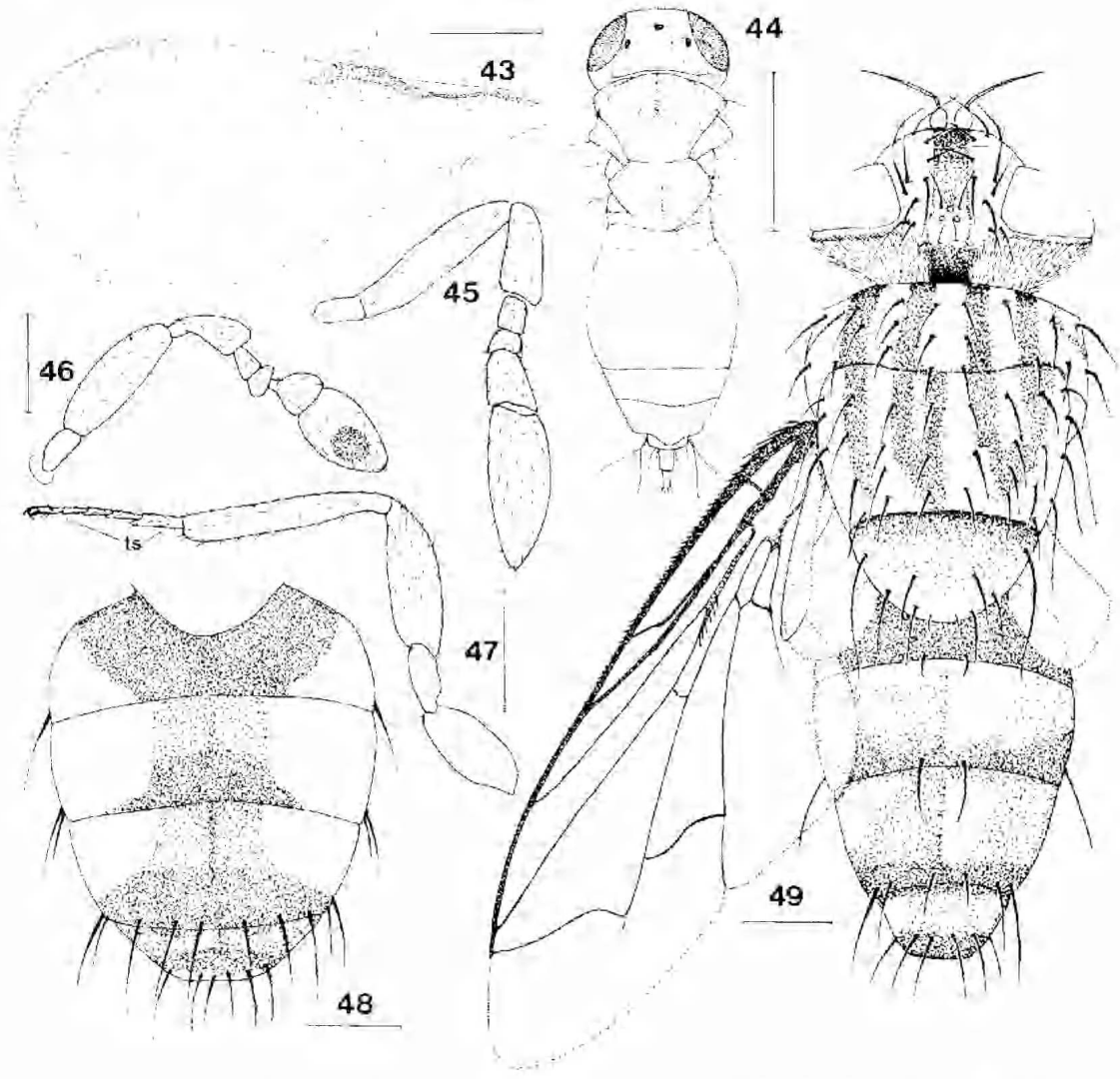
Eupelmidae (genus & species indet.)
FIG. 32

A single male specimen reared as a hyperparasitoid of *U. lugens* through *C. urabae* in the Adelaide region could not be identified to genus, but it is not *Anastatus* sp., from which it can be separated by the characters in the key.

Family Trichogrammatidae

Trichogramma sp.
FIGS 39–42

The members of this cosmopolitan genus are



Figs 43–49. 43–47, *Centrodora* sp.: 43, Fore wing, ♀; 44, Dorsal view of whole body, ♀; 45, ♀ antenna; 46, ♂ antenna; 47, Hind leg, ♀; 48, Abdomen of *Winthemia lateralis*, ♀ (Macquart); 49, Dorsal view of *Exorista fluviceps* Macquart, ♀ (stippling showing colour pattern in Figures 46 and 47). Scales: Fig. 43 = 200 μm; Fig. 44 = 300 μm; Figs 45–47 = 50 μm (same scale line for Figs 45 and 46); Figs 48 and 49 = 1.0 mm. Abbreviation: ts = tarsal segments.

obligate, primary parasitoids of insect eggs, most frequently those of Lepidoptera. It is the only egg parasitoid of *U. lugens* so far recorded, and it can be identified by the characters in the key, as well as its minute size, distinctive fore wing venation, fore wing setal pattern, and very narrow hind wing. This species is a solitary parasitoid known only from the Adelaide region. We have not seen material of the *Trichogramma* sp. reared from *U. lugens* in the Murray Valley in N.S.W. (Campbell 1962), which may be the same species to that recorded here.

Family Aphelinidae

Centrodora sp.
FIGS 43–47

This is a cosmopolitan genus of about 40 described species (Hayat 1983), most of which are primary parasitoids of the eggs of Orthoptera and Homoptera, although at least one species is reported to be hyperparasitic (Gordh 1979; also see Viggiani 1984). The species recorded here is an obligate, gregarious hyperparasitoid of *U. lugens*

through *C. urabae* or *D. eucalypti*. Apart from the characters in the key and the life history stage attacked, *Centrodora* sp. can be separated from the other parasitoids associated with *U. lugens* by its minute size, wing venation, and ovipositor which is more than half the length of the gaster (the ovipositor being significantly less than half the gastral length in *Trichogramma* sp.).

DIPTERA

Family Tachinidae

Winthemia lateralis (Macquart)
FIG. 48

Previously this species has been collected at various localities in all states of Australia. It has been reared from host species belonging to seven lepidopteran families, viz. Arctiidae, Noctuidae, Pieridae, Notodontidae, Nymphalidae, Saturnidae and Geometridae (Crosskey 1973; Cantrell 1986, 1989). The only record from *U. lugens* is from specimens in this study (3 specimens, Waite Institute campus, J. Cobbinah, 1975, WARI). *W. lateralis* oviposits onto the external surface of a host larva. After hatching the fly larva penetrates the host larva and usually emerges from the host pupa, although we were not able to confirm its biology in this study. See Crosskey (1973) and Cantrell (1986, 1989) for additional taxonomic information and list of synonyms.

Exoristu flaviceps Macquart
FIG. 49

This species has been recorded from all states of Australia and the N.T. (Cantrell 1985), and has been reared from members of nine lepidopteran families, viz. Lymantriidae, Anthelidae, Pieridae, Agaristidae, Sphingidae, Geometridae, Notodontidae, Lasiocampidae and Noctuidae (Crosskey 1973; Cantrell 1986). It oviposits onto the surface of *U. lugens* larvae. After hatching the fly larva burrows into the host to feed and develop internally, finally emerging from late larval instars to pupate outside the dead host. The colour pattern on the abdomen and occiput of the head is the easiest way to distinguish this species from *W. lateralis*. See Cantrell (1985) for additional taxonomic information and list of synonyms.

Other Parasitoids

From *U. lugens* in Queensland Brimblecombe (1962) reared two ichneumonoid species which have not been recorded in S. Aust., viz. *Irabatha* sp. (Ichneumonidae) and *Campyloneura* sp. (Braconidae). Also Gauld (1984) reports the following ichneumonids as having been reared from *U. lugens*: *Stiromesostenus* spp., *Campoplex* sp. and *Pristomerus* sp., but again, they were not reared during this study and may not be found in S. Aust.

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